

इंटरनेट

मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”

Mazdoor Kisan Shakti Sangathan

“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”

Jawaharlal Nehru

“Step Out From the Old to the New”

IS 11948 (2010): AUTOMOTIVE VEHICLES — STEERING EFFORT —
METHOD OF EVALUATION [TED 4: Automotive Braking Systems]



“ज्ञान से एक नये भारत का निर्माण”

Satyanarayan Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE



भारतीय मानक
स्वचल वाहन — स्टीयरिंग प्रयास — मूल्यांकन पद्धति
(दूसरा पुनरीक्षण)

Indian Standard
AUTOMOTIVE VEHICLES — STEERING
EFFORT — METHOD OF EVALUATION
(*Second Revision*)

ICS 43.040.50

© BIS 2010

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Braking Systems, Vehicle Testing and Performance Evaluation Sectional Committee had been approved by the Transport Engineering Division Council.

The overall performance of an automotive vehicle is a function of the performance of its various systems and components. The steering system is one of the main systems that directly contribute to the active safety of the driver and the other road users.

This standard was first published in 1986 and was first revised in 1999. This revision has been taken up to align the standard with ECE Regulation 79 — Revision 2 Amendment 2. This revised standard additionally considers the following:

- a) Provisions for trailers and the trailers with hydraulic steering transmissions.
- b) Braking performance for vehicles using the same energy source to supply steering equipment and braking device (*see* Annex A).
- c) Additional provisions for vehicles equipped with auxiliary steering equipment.
- d) Special requirements to be applied for the safety aspects of complex electronic vehicle control systems.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

AUTOMOTIVE VEHICLES — STEERING EFFORT — METHOD OF EVALUATION

(*Second Revision*)

1 SCOPE

1.1 This standard specifies the method of evaluation of steering efforts of automotive vehicles. This standard applies to the steering equipment of vehicles of categories M, N and O as defined in IS 14272 (Part 1) : 1995 'Automotive vehicles — Types — Terminology: Part 1 Three and four wheelers'.

1.2 This standard does not apply to,

- a) steering equipment with a purely pneumatic transmission;
- b) autonomous steering systems as defined in **3.3.3**;
- c) full power steering systems fitted to trailers where the energy necessary for operation is transmitted from the towing vehicle; and
- d) the electrical control of full power steering systems fitted to trailers, other than additional steering equipment as defined in **3.5.2.4**.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of the standard. At the time of publication, the edition indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standard indicated below:

<i>IS No.</i>	<i>Title</i>
7079 : 2008	Automotive vehicles — Brake hose assemblies for hydraulic braking systems used with non-petroleum base brake fluid — Specification (<i>third revision</i>)
14272 (Part 1) : 1995	Automotive vehicles — Types — Terminology: Part 1 Three and four wheelers
ISO 2575 : 2004	Road vehicles — Symbols for controls, indicators and tell-tales

3 DEFINITIONS

For the purposes of this standard the following definitions shall apply.

3.1 Approval of a Vehicle, means the approval of a vehicle type with regard to its steering equipment.

3.2 Vehicle Type, means the vehicle, which does not differ with respect to the manufacturer's designation of the vehicle type and in essential characteristics, such as type of steering equipment, steering control, steering transmission, steered wheels, and energy source.

3.3 Steering Equipment, means all the equipment the purpose of which is to determine the direction of movement of the vehicle. The steering equipment consists of steering control, steering transmission, steered wheels and the energy supply, if any.

3.3.1 Steering Control, means the part of the steering equipment, which controls its operation, it may be operated with or without direct intervention of the driver. For steering equipment in which the steering forces are provided solely or partly by the muscular effort of the driver the steering control includes all parts up to the point where the steering effort is transformed by mechanical, hydraulic or electrical means.

3.3.2 Steering Transmission, means all components, which form a functional link between the steering control and the road wheels. The transmission is divided into two independent functions.

The control transmission and the energy transmission. Where the term transmission is used alone in this standard, it means both the control transmission and the energy transmission. A distinction is drawn between mechanical, electrical and hydraulic transmission systems or combinations thereof, according to the means by which the signals and/or energy is transmitted.

3.3.2.1 Control transmission, means all components by means of which signals are transmitted for control of the steering equipment.

3.3.2.2 Energy transmission, means all components by means of which the energy required for control/Standard of the steering function of the wheels is transmitted.

3.3.3 Autonomous Steering System, means a system

that incorporates a function within a complex electronic control system that causes the vehicle to follow a defined path or to alter its path in response to signals initiated and transmitted from off-board the vehicle. The driver will not necessarily be in primary control of the vehicle.

3.3.4 Advanced Driver Assistance Steering System, means a system, additional to the main steering system, that provides assistance to the driver in steering the vehicle but in which the driver remains at all times in primary control of the vehicle. It comprises one or both of the following functions:

3.3.4.1 Automatically commanded steering function, means the function within a complex electronic control system where actuation of the steering system can result from automatic evaluation of signals initiated on-board the vehicle, possibly in conjunction with passive infrastructure features, to generate continuous control action in order to assist the driver in following a particular path, in low speed manoeuvring or parking operations.

3.3.4.2 Corrective steering function, means the discontinuous control function within a complex electronic control system whereby, for a limited duration, changes to the steering angle of one or more wheels may result from the automatic evaluation of signals initiated on-board the vehicle, in order to maintain the basic desired path of the vehicle or to influence the vehicle's dynamic behaviour. Systems that do not themselves positively actuate the steering system but that, possibly in conjunction with passive infrastructure features, simply warn the driver of a deviation from the ideal path of the vehicle, or of an unseen hazard, by means of a tactile warning transmitted through the steering control, are also considered to be corrective steering.

3.3.5 Steered Wheels, means the wheels the alignment of which may be altered directly or indirectly in relation to the longitudinal axis of the vehicle in order to determine the direction of movement of the vehicle. (The steered wheels include the axis around which they are rotated in order to determine the direction of movement of the vehicle.)

3.3.6 Energy Supply, includes those parts of the steering equipment, which provide it with energy, regulate that energy and where appropriate, process and store it. It also includes any storage reservoirs for the operating medium and the return lines, but not the vehicle's engine or its drive to the energy source.

3.3.6.1 Energy source, means the part of the energy supply, which provides the energy in the required form.

3.3.6.2 Energy reservoir, means that part of the energy supply in which the energy provided by the energy

source is stored, for example, a pressurized fluid reservoir or vehicle battery.

3.3.6.3 Storage reservoir, means that part of the energy supply in which the operating medium is stored at or near to the atmospheric pressure, for example a fluid reservoir.

3.4 Steering Parameters

3.4.1 Steering Control Effort, means the force applied to the steering control in order to steer the vehicle.

3.4.2 Steering Time, means the period of time from the beginning of the movement of the steering control to the moment at which the steered wheels have reached a specific steering angle.

3.4.3 Steering Angle, means the angle between the projection of a longitudinal axis of the vehicle and the line of intersection of the wheel plane (being the central plane of the wheel, normal to the axis around which it rotates) and the road surface.

3.4.4 Steering Forces, mean all the forces operating in the steering transmission.

3.4.5 Mean Steering Ratio, means the ratio of the angular displacement of the steering control to the mean of the swept steering angle of the steered wheels for a full lock-to-lock turn.

3.4.6 Turning Circle, means the circle within which are located the projections onto the ground plane of all the points of the vehicle, excluding the external mirrors and the front direction indicators, when the vehicle is driven in a circle.

3.4.7 Nominal Radius of Steering Control, means in the case of a steering wheel the shortest dimension from its centre of rotation to the outer edge of the rim. In the case of any other form of control it means the distance between its centre of rotation and the point at which the steering effort is applied. If more than one such point is provided, the one requiring the greatest effort shall be used.

3.5 Types of Steering Equipment

Depending on the way the steering forces are produced, the following types of equipment are distinguished:

3.5.1 For Motor Vehicles

3.5.1.1 Main steering system, means the steering equipment of a vehicle, which is mainly responsible for determining the direction of travel. It may comprise:

3.5.1.1.1 Manual steering equipment, in which the steering forces result solely from the muscular effort of the driver.

3.5.1.1.2 Power assisted steering equipment, in which the steering forces result from both the muscular effort of the driver and the energy supply (supplies). Steering equipment in which the steering forces result solely, from one or more energy supplies when the equipment is intact, but in which the steering forces can be provided by the muscular effort of the driver alone if there is a fault in the steering (integrated power systems), is also considered to be power assisted steering equipment.

3.5.1.1.3 Full-power steering equipment, in which the steering forces are provided solely by one or more energy supplies.

3.5.1.2 Self-tracking steering equipment, means a system designed to create a change of steering angle on one or more wheels only when acted upon by forces and/or moments applied through the tyre to road contact.

3.5.1.3 Auxiliary steering equipment (ASE), means a system in which the wheels on axle(s) of vehicles of Categories M and N are steered in addition to the wheels of the main steering equipment in the same or opposite direction to those of the main steering equipment and/or the steering angle of the front and/or the rear wheels may be adjusted relative to vehicle behaviour.

3.5.2 For Trailers

3.5.2.1 Self-tracking steering equipment, means a system designed to create a change of steering angle on one or more wheels only when acted upon by forces and/or moments applied through the tyre to road contact.

3.5.2.2 Articulated steering, means equipment in which the steering forces are produced by a change in direction of the towing vehicle and in which the movement of the steered trailer wheels is firmly linked to the relative angle between the longitudinal axis of the towing vehicle and that of the trailer.

3.5.2.3 Self-steering, means equipment in which the steering forces are produced by a change in direction of the towing vehicle and in which the movement of the steered trailer wheels is firmly linked to the relative angle between the longitudinal axis of the trailer frame or a load replacing it and the longitudinal axis of the sub-frame to which the axle(s) is (are) attached.

3.5.2.4 Additional steering equipment, means a system, independent of the main steering system, by which the steering angle of one or more axle(s) of the steering system can be influenced selectively for manoeuvring purposes.

3.5.3 Steering Equipment

Depending on the arrangement of the steered wheels, the following types of steering equipment are distinguished:

3.5.3.1 Front-wheel steering equipment, in which only the wheels of the front axle(s) are steered. This includes all wheels which are steered in the same direction.

3.5.3.2 Rear-wheel steering equipment, in which only the wheels of the rear axle(s) are steered. This includes all wheels which are steered in the same direction.

3.5.3.3 Multi-wheel steering equipment, in which the wheels of one or more of each of the front and the rear axle(s) are steered.

3.5.3.3.1 All-wheel steering equipment, in which all the wheels are steered.

3.5.3.3.2 Buckle steering equipment, in which the movement of chassis parts relative to each other is directly produced by the steering forces.

3.6 Types of Steering Transmission

Depending on the way the steering forces are transmitted, the following types of steering transmission are distinguished:

3.6.1 Purely Mechanical Steering Transmission, means a steering transmission in which the steering forces are transmitted entirely by mechanical means.

3.6.2 Purely Hydraulic Steering Transmission, means a steering transmission in which the steering forces, somewhere in the transmission, are transmitted only by hydraulic means.

3.6.3 Purely Electric Steering Transmission, means a steering transmission in which the steering forces, somewhere in the transmission, are transmitted only through electric means.

3.6.4 Hybrid Steering Transmission, means a steering transmission in which part of the steering forces are transmitted through one and the other part through another of the above mentioned means. However, in the case where any mechanical part of the transmission is designed only to give position feedback and is too weak to transmit the total sum of the steering forces, this system shall be considered to be purely hydraulic or purely electric steering transmission.

3.7 Electric Control Line

Means the electrical connection which provides the steering control function to the trailer. It comprises the electrical wiring and connector and includes the parts for data communication and the electrical energy supply for the trailer control transmission.

4 CONSTRUCTION PROVISIONS

4.1 General Provisions

4.1.1 The steering equipment shall ensure easy and safe handling of the vehicle up to its maximum design speed or in case of a trailer up to its technically permitted maximum speed. There must be a tendency to self-centre when tested in accordance with 5.2 with the intact steering equipment. The vehicle shall meet the requirements of 5.2 in the case of motor vehicles and of 5.3 in the case of trailers. If a vehicle is fitted with an auxiliary steering system (ASE), it shall also meet the requirements of Annex B. Trailers equipped with hydraulic steering transmissions shall also comply with Annex C.

4.1.2 It must be possible to travel along a straight section of road without unusual steering correction by the driver and without unusual vibration in the steering system at the maximum design speed of the vehicle.

4.1.3 The direction of operation of the steering control shall correspond to the intended change of direction of the vehicle and there shall be a continuous relationship between the steering control deflection and the steering angle. These requirements do not apply to systems that incorporate an automatically commanded or corrective steering function, or to auxiliary steering equipment. These requirements may also not necessarily apply in the case of full power steering when the vehicle is stationary and when the system is not energized.

4.1.4 The steering equipment shall be designed, constructed and fitted in such a way it is capable of withstanding the stresses arising during normal operation of the vehicle, or combination of vehicles. The maximum steering angle shall not be limited by any part of the steering transmission unless specifically designed for this purpose. Unless otherwise specified, it will be assumed that for the purpose of this standard, not more than one failure can occur in the steering equipment at any one time and two axles on one bogie shall be considered as one axle.

4.1.5 The effectiveness of the steering equipment, including the electrical control lines, shall not be adversely affected by magnetic or electric fields.

4.1.6 Advanced driver assistance steering systems shall only be approved in accordance with this standard where the function does not cause any deterioration in the performance of the basic steering system. In addition they shall be designed such that the driver may, at any time and by deliberate action, override the function.

4.1.6.1 Whenever the automatically commanded steering function becomes operational, this shall be indicated to the driver and the control action shall be automatically disabled if the vehicle speed exceeds the set limit of 10 km/h by more than 20 percent or the signals to be evaluated are no longer being received. Any termination of control shall produce a short but distinctive driver warning by a visual signal and either an acoustic signal or by imposing a tactile warning signal on the steering control.

4.1.7 Steering Transmission

4.1.7.1 Adjustment devices for steering geometry must be such that after adjustment a positive connection can be established between the adjustable components by appropriate locking devices.

4.1.7.2 Steering transmission, which can be disconnected to cover different configurations of a vehicle (for example on extendable semi-trailers), must have locking devices, which ensure positive relocation of components; where locking is automatic, there must be an additional safety lock which is operated manually.

4.1.8 Steered Wheels

The steered wheels shall not be solely the rear wheels. This requirement does not apply to semi-trailers.

4.1.9 Energy Supply

The same energy supply may be used for the steering equipment and other systems. However in the case of a failure in any system which shares the same energy supply steering shall be ensured in accordance with the relevant failure conditions of 4.3.

4.1.10 Control Systems

The requirements of Annex D shall be applied to the safety aspects of electronic vehicle control systems that provide or form part of the control transmission of the steering function including advanced driver assistance steering systems. However, systems or functions, that use the steering system as the means of achieving a higher level objective, are subject to Annex D only insofar as they have a direct effect on the steering system. If such systems are provided, they shall not be deactivated during type approval testing of the steering system.

4.2 Special Provisions for Trailers

4.2.1 Trailers (with the exception of semi-trailers and centre-axle trailers) which have more than one axle with steered wheels and semi-trailers and centre-axle trailers which have at least one axle with steered wheels must fulfil the conditions given in 5.3. However, for trailers with self-tracking steering equipment a test

under 5.3 is not necessary if the axle load ratio between the un-steered and the self-tracking axles equals or exceeds 1.6 under all loading conditions. However for trailers with self-tracking steering equipment, the axle load ratio between un-steered or articulated steered axles and friction-steered axles shall be at least 1 under all loading conditions.

4.2.2 If the towing vehicle of a vehicle combination is driving straight ahead, the trailer and towing vehicle must remain aligned. If alignment is not retained automatically, the trailer must be equipped with a suitable adjustment facility for maintenance.

4.3 Failure Provisions and Performance

4.3.1 General

4.3.1.1 For the purposes of this standard, the steered wheels, the steering control and all mechanical parts of the steering transmission shall not be regarded as liable to breakage if they are amply dimensioned, are readily accessible for maintenance, and exhibit safety features at least equal to those prescribed for other essential components (such as the braking system) of the vehicle. Where the failure of any such part would be likely to result in loss of control of the vehicle, that part must be made of metal or of a material with equivalent characteristics and must not be subject to significant distortion in normal operation of the steering system.

4.3.1.2 The requirements of 4.1.2, 4.1.3 and 5.2.1 shall also be satisfied with a failure in the steering equipment as long as the vehicle can be driven with the speeds required in the respective clauses. In this case 4.1.3 shall not apply for full power steering systems when the vehicle is stationary.

4.3.1.3 Any failure in a transmission other than purely mechanical must clearly be brought to the attention of the vehicle driver as given in 4.4.

4.3.1.4 In the case where the braking system of the vehicle shares the same energy source as the steering system and this energy source fails, the steering system shall have priority and shall be capable of meeting the requirements of 4.3.2 and 4.3.3 as applicable. In addition the braking performance on the first subsequent application shall not drop below the prescribed service brake performance, as given in Annex A.

4.3.1.5 In the case where the braking system of the vehicle shares the same energy supply as the steering system and there is a failure in the energy supply, the steering system shall have priority and shall be capable of meeting the requirements of 4.3.2 and 4.3.3 as applicable. In addition the braking performance on the

first subsequent application shall comply with the requirements of A-3.

4.3.1.6 In the case of trailers the requirements of 4.2.2 and 5.3.4.1 shall also be met when there is a failure in the steering system.

4.3.2 Power Assisted Steering Systems

4.3.2.1 Should the engine stop or a part of the transmission fail, with the exception of those parts listed in 4.3.1.1, there shall be no immediate changes in steering angle. As long as the vehicle is capable of being driven at a speed greater than 10 km/h the requirements given in 5, relating to a system with a failure, shall be met.

4.3.3 Full Power Steering Systems

4.3.3.1 The system shall be designed such that the vehicle cannot be driven indefinitely at speeds above 10 km/h where there is any fault which requires operation of the warning signal referred to in 4.4.2.1.

4.3.3.2 In case of a failure within the control transmission, with the exception of those parts listed in 4.1.4, it shall still be possible to steer with the performance laid down in 7 for the intact steering system.

4.3.3.3 In the event of a failure of the energy source of the control transmission, it shall be possible to carry out at least 24 'figure of eight' manoeuvres, where each loop of the figure is 40 m diameter at 10 km/h speed and at the performance level given for an intact system in 5. The test manoeuvres shall begin at an energy storage level given in 4.3.3.5.

4.3.3.4 In the event of a failure within the energy transmission, with the exception of those parts listed in 4.3.1.1, there shall not be any immediate changes in steering angle. As long as the vehicle is capable of being driven at a speed greater than 10 km/h the requirements of 5 for the system with a failure shall be met after the completion of at least 25 'figure of eight' manoeuvres at 10 km/h minimum speed, where each loop of the figure is 40 m diameter. The test manoeuvres shall begin at an energy storage level given in 4.3.3.5.

4.3.3.5 The energy level to be used for the tests referred to in 4.3.3.3 and 4.3.3.4 shall be the energy storage level at which a failure is indicated to the driver. In the case of electrically powered systems subject to Annex D, this level shall be the worst case situation outlined by the manufacturer in the documentation submitted in connection with Annex D and shall take into account the effects of, for example temperature and ageing on battery performance.

4.4 Warning Signals

4.4.1 General Provisions

4.4.1.1 Any fault which impairs the steering function and is not mechanical in nature must be signaled clearly to the driver of the vehicle. Despite the requirements of **4.1.2** the deliberate application of vibration in the steering system may be used as an additional indication of a fault condition in this system.

In the case of a motor vehicle, an increase in steering force is considered to be a warning indication; in the case of a trailer, a mechanical indicator is permitted.

4.4.1.2 If the same energy source is used to supply the steering system and other systems, an acoustic or optical warning shall be given to the driver, when the stored energy/fluid in the energy/storage reservoir drops to a level liable to cause an increase in steering effort. This warning may be combined with a device provided to warn of brake failure if the brake system uses the same energy source. The satisfactory condition of the warning device must be easily verifiable by the driver.

4.4.2 Special Provisions for Full-Power Steering Equipment

4.4.2.1 Power-driven vehicles shall be capable of providing steering failure and defect warning signals, as follows:

- a) A red warning signal, indicating failures defined in **4.3.1.3** within the main steering equipment.
- b) Where applicable, a yellow warning signal indicating an electrically detected defect within the steering equipment, which is not indicated by the red warning signal.
- c) If a symbol is used, it must comply with Symbol J 04, ISO/IEC registration number 7000-2441 as defined in ISO 2575.
- d) The warning signal(s) mentioned above shall light up when the electrical equipment of the vehicle (and the steering system) is energized. With the vehicle stationary, the steering system shall verify that none of the specified failures or defects is present before extinguishing the signal. Specified failures or defects which should activate the warning signal mentioned above, but which are not detected under static conditions, shall be stored upon detection and be displayed at start-up and at all times when the ignition (start) switch is in the 'on' (run) position, as long as the failure persists.

4.4.3 In the case where additional steering equipment is in operation and/or where the steering angle

generated by that equipment has not been returned to normal driving position a warning signal must be given to the driver.

5 TEST PROVISIONS

5.1 General Provisions

5.1.1 The test shall be conducted on a level surface affording good adhesion.

5.1.2 During the test(s) the vehicle shall be loaded to its technically permissible maximum mass and its technically permissible maximum load on the steered axle(s).

In the case of axles fitted with auxiliary steering equipment (ASE), this test shall be repeated with the vehicle loaded to its technically permissible maximum mass and the axle equipped with ASE loaded to its maximum permissible load.

5.1.3 Before the test begins, the tyre pressures shall be as prescribed by the manufacturer for the mass specified in **5.1.2** when the vehicle is stationary.

5.1.4 In the case of any systems that use electrical energy for part or all of the energy supply, all performance tests shall be carried out under conditions of actual or simulated electrical load of all essential systems or systems components, which share the same energy supply. Essential systems shall comprise at least lighting systems, windscreen wipers, engine management and braking systems.

5.2 Provisions for Motor Vehicles

5.2.1 It must be possible to leave a curve with a radius of 50 m at a tangent without unusual vibration in the steering equipment at the following speed:

Category M₁ vehicles: 50 km/h Category M₂, M₃, N₁, N₂ and N₃ vehicles: 40 km/h or the maximum design speed if this is below the speeds given above.

5.2.2 When the vehicle is driven in a circle with its steered wheels at approximately half lock and at a constant speed of at least 10 km/h, the turning circle must remain the same or become larger if the steering control is released.

5.2.3 During the measurement of the control effort, forces with duration of less than 0.2 s shall not be taken into account.

5.2.4 Measurement of Steering Efforts on Motor Vehicles with Intact Steering Equipment

5.2.4.1 The vehicle shall be driven from straight ahead into a spiral at a speed of 10 km/h. The steering effort shall be measured at the nominal radius of the steering control until the position of the steering control

corresponds to turning radius given in the table below for the particular category of vehicle with intact steering. One steering movement shall be made to the right and one to the left.

5.2.4.2 The maximum permitted steering time and the maximum permitted steering control effort with intact steering equipment are given in the table below for each category of vehicle.

5.2.5 Measurement of Steering Efforts on Motor Vehicles with a Failure in the Steering Equipment

5.2.5.1 The test described in 5.2.4 shall be repeated with a failure in the steering equipment. The steering effort shall be measured until the position of the steering control corresponds to the turning radius given in the table below for the particular category of vehicle with a failure in the steering equipment.

5.2.5.2 The maximum permitted steering time and the maximum permitted steering control effort with a failure in the steering equipment are given in the Table 1 for each category of vehicle.

5.3 Provisions for Trailers

5.3.1 The trailer must travel without excessive deviation or unusual vibration in its steering equipment when the towing vehicle is travelling in a straight line on a flat and horizontal road at a speed of 80 km/h or the technically permissible maximum speed indicated by the trailer manufacturer if this is less than 80 km/h.

5.3.2 With the towing vehicle and trailer having adopted a steady state turn corresponding to a turning circle radius of 25 m (see 3.4.6) at a constant speed of 5 km/h, the circle described by the rearmost outer edge of the trailer shall be measured. This manoeuvre shall be repeated under the same conditions but at a speed of 25 ± 1 km/h. During these manoeuvres, the rearmost outer edge of the trailer travelling at a speed of 25 ± 1 km/h shall not move outside the circle described at a constant speed of 5 km/h by more than 0.7 m.

5.3.3 No part of the trailer must move more than 0.5 m beyond the tangent to a circle with a radius of 25 m when towed by a vehicle leaving the circular path described in 5.3.2 along the tangent and travelling at a speed of 25 km/h. This requirement must be met from the point the tangent meets the circle to a point 40 m along the tangent. After that point the trailer must fulfill the condition specified in 5.3.1.

5.3.4 The annular ground area swept by the towing vehicle/trailer combination with an intact steering system, driving at no more than 5 km/h in a constant radius circle with the front outer corner of the towing vehicle describing a radius of $0.67 \times$ vehicle combination length but not less than 12.5 m is to be measured.

5.3.4.1 If, with a fault in the steering system, the measured swept annular width is greater than 8.3 m, then this shall not be an increase of more than 15 percent compared with the corresponding value measured with the intact steering system. There shall not be any increase in the outer radius of the swept annular width.

5.3.5 The tests described in 5.3.2, 5.3.3 and 5.3.4 shall be conducted in both clockwise and anti-clockwise directions.

6 VEHICLE CHARACTERISTICS

Vehicle characteristics declared by the vehicle manufacturer to the testing agency shall contain at least the details given in Annex E.

NOTE — If the vehicle, submitted for type approval of the vehicle contain details given in Annex A, it is not necessary to submit them again.

7 CHANGES IN VEHICLE CHARACTERISTICS

7.1 In case the test is conducted for verification of compliance to statutory requirements the following shall be carried out.

7.2 Every modification to vehicle characteristics

Table 1 Steering Control Effort Requirements
(Clause 5.2.5.2)

Sl No.	Vehicle Category	Intact			With a Failure		
		Maximum Effort daN	Time s	Turning Radius m	Maximum Effort daN	Time s	Turning Radius m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	M ₁	15	4	12	30	4	20
ii)	M ₂	15	4	12	30	4	20
iii)	M ₃	20	4	12 ¹⁾	45 ²⁾	6	20
iv)	N ₁	20	4	12	30	4	20
v)	N ₂	25	4	12	40	4	20
vi)	N ₃	20	4	12 ¹⁾	45 ²⁾	6	20

¹⁾ Or full lock, if 12 m radius is not attainable.

²⁾ 50 for rigid vehicles with 2 or more steered axles excluding self-tracking equipment.

declared in accordance with 6 shall be intimated by the manufacturer to the testing agency.

The testing agency may then consider, whether,

- a) the model with changes specifications still complies with the requirements of this standard, or
- b) any further verification is required to establish compliance to this standard.

7.3 Changes where testing is considered necessary for establishing compliance to this standard are as follows:

- a) Any increase of weight on steered axle in excess of 10 percent in case of M_1 and N_1 type of vehicles and 5 percent for other vehicles.
- b) Any increase in wheel base in excess of 10 percent incase of M_1 and N_1 type of vehicles and 5 percent for other vehicles.
- c) Any decrease in steering wheel diameter [see 7.3 (a)].
- d) Any change in steering linkage/steering gear box ratio which decreases the number of turns of steering wheel from lock to lock.

- e) Type of construction of steering gear box (such as re-circulating ball type to rack and pinion type, power steering, etc).
- f) An increase of caster angle.
- g) Increase of tyre size.
- h) Change of tyre type from diagonal or cross ply to radial ply.
- j) Any change in wheel lock angle that affects the test turning circle.
- k) Increase in number of axles.
- m) If steered axle becomes driven:
 - 1) In the case of decrease in the steering wheel diameter, if the effort calculated from the previous test using the new steering wheel diameter is within limits, are re-test need not be carried out.
 - 2) Change other than those listed above, are considered to be having no adverse effect on steering effort.
 - 3) In 7.2 (a) or after results of further verification as per 7.2 (b) are successful, the test results shall be validated for the changes carried out.

ANNEX A

(Foreword and Clause 4.3.1.4)

BRAKING PERFORMANCE FOR VEHICLES USING THE SAME ENERGY SOURCE TO SUPPLY STEERING EQUIPMENT AND BRAKING DEVICE

A-1 For tests carried out in accordance with this Annex the following vehicle conditions shall be met.

A-1.1 The vehicle shall be loaded to its technically permissible maximum mass distributed between the axles as declared by the vehicle manufacturer. Where provision is made for several arrangements of the mass on the axles, the distribution of the maximum mass between the axles shall be such that the mass on each axle is proportional to the maximum permissible mass for each axle. In the case of tractors for semi-trailers, the mass may be repositioned approximately half way between the kingpin position resulting from the above loading conditions and the centreline of the rear axle(s);

A-1.2 The tyres shall be inflated to the cold inflation pressure prescribed for the mass to be borne by the tyres when the vehicle is stationary; and

A-1.3 Before the start of the tests the brakes shall be cold, that is, with a disc or outer brake drum surface temperature less than 100°C.

A-2 If an energy source failure occurs, service braking performance on the first brake application shall achieve the values given in Table 2.

Table 2 Service Braking Performance

Sl No.	Category	V km/h	m/s ²	F daN
(1)	(2)	(3)	(4)	(5)
i)	M_1	80	5.8	50
ii)	M_2 and M_3	60	5.0	70
iii)	N_1	80	5.0	70
iv)	N_2 and N_3	60	5.0	70

A-3 After any failure in the steering equipment, or the energy supply, it shall be possible after eight full stroke actuation's of the service brake control, to achieve at the ninth application, at least the performance prescribed for the secondary (emergency) braking system (*see* Table 3). In the case where secondary performance requiring the use of stored energy is achieved by a separate control, it shall still be possible after eight full stroke actuation's of the service brake control to achieve at the ninth application, the residual performance (*see* Table 3).

Table 3 Secondary and Residual Efficiency
(*Clause A-3*)

Sl No.	Category	V (km/h)	Secondary Braking	Residual Braking
(1)	(2)	(3)	(4)	(5)
i)	M ₁	80	2.9	1.7
ii)	M ₂	60	2.5	1.5
iii)	M ₃	60	2.5	1.5
iv)	N ₁	70	2.2	1.3
v)	N ₂	50	2.2	1.3
vi)	N ₃	40	2.2	1.3

ANNEX B

(*Clause 4.1.1*)

ADDITIONAL PROVISIONS FOR VEHICLES EQUIPPED WITH ASE

B-1 GENERAL PROVISIONS

Vehicles fitted with auxiliary steering equipment (ASE) in addition to the requirements given in the body of this standard shall also comply with the provisions of this Annex.

B-2 SPECIFIC PROVISIONS

B-2.1 Transmission

B-2.1.1 *Mechanical Steering Transmissions*
(*see 4.3.1.1*)

B-2.1.2 *Hydraulic Steering Transmissions*

The hydraulic steering transmission must be protected from exceeding the maximum permitted service pressure T .

B-2.1.3 *Electric Steering Transmissions*

The electric steering transmission must be protected from excess energy supply.

B-2.1.4 *Combination of Steering Transmissions*

A combination of mechanical, hydraulic and electric transmissions shall comply with the requirements specified in **B-2.1.1**, **B-2.1.2** and **B-2.1.3**.

B-2.2 Testing Requirements for Failure

B-2.2.1 Malfunction or failure of any part of the ASE (except for parts not considered to be susceptible to breakdown as specified in **4.3.1.1**) shall not result in a sudden significant change in vehicle behaviour and the relevant requirements of **5** shall still be met.

Furthermore, it must be possible to control the vehicle without abnormal steering correction. This shall be verified by the following tests:

B-2.2.1.1 Circular test

The vehicle shall be driven into a test circle with a radius R (m) and a speed V (km/h) corresponding to its category and the values given in the Table 4. The failure shall be introduced when the specified test speed has been reached. The test shall include driving in a clockwise direction and in a counter-clockwise direction.

Table 4 Circular Test

Sl No.	Vehicle Category	$R^{1)}$	$V^{2)3)}$
(1)	(2)	(3)	(4)
i)	M ₁ and N ₁	100	80
ii)	M ₂ and N ₂	50	50
iii)	M ₃ and N ₃	50	45

¹⁾ If, due to the configuration of the test site, the values of the radii cannot be observed, the tests may be carried out on tracks with other radii, (maximum variation: ± 25 percent) provided that the speed is varied to obtain the transverse acceleration resulting from the radius and speed indicated in the table for the particular category of vehicle.

²⁾ If the ASE is in a mechanically locked position at this specified speed, the test speed will be modified to correspond to the maximum speed where the system is functioning. Maximum speed means the speed when the ASE becomes locked, minus 5 km/h.

³⁾ If the dimensional characteristics of the vehicle imply an overturning risk, the manufacturer shall provide to the Technical Service behaviour simulation data demonstrating a lower maximum safe speed for conducting the test. Then the Technical Service will choose this test speed.

B-2.2.1.2 Transient test

Until uniform test procedures have been agreed, the vehicle manufacturer shall provide the technical services with their test procedures and results for transient behaviour of the vehicle in the case of failure.

B-2.3 Warning Signals in Case of Failure

Except for parts of ASE not considered susceptible to

breakdown as specified in **4.3.1.1**, the following failure of ASE shall be clearly brought to the attention of the driver:

- a) A general cut-off of the ASE electrical or hydraulic control,
- b) Failure of the ASE energy supply, and
- c) A break in the external wiring of the electrical control, if fitted.

ANNEX C

(*Clause 4.1.1*)

PROVISIONS FOR TRAILERS HAVING HYDRAULIC STEERING TRANSMISSIONS

C-1 GENERAL PROVISIONS

Vehicles fitted with hydraulic steering transmission, in addition to the requirements given in the body of this standard shall also comply with the provisions of this Annex.

C-2 SPECIFIC PROVISIONS

C-2.1 Performance of Hydraulic Lines and Hose Assemblies

C-2.1.1 The hydraulic lines of hydraulic transmission shall be capable of a burst pressure at least four times the maximum normal service pressure (T) specified by

the vehicle manufacturer. Hose assemblies shall comply with IS 7079.

C-2.2 In systems dependent on an energy supply.

C-2.2.1 The energy supply must be protected from excess pressure by a pressure limiting valve which operates at the pressure T .

C-2.3 Protection of Steering Transmission

C-2.3.1 The steering transmission must be protected from excess pressure by a pressure limiting valve which operates at between $1.5 T$ and $2.2 T$.

ANNEX D

(*Clause 4.1.10*)

SPECIAL REQUIREMENTS TO BE APPLIED TO THE SAFETY ASPECTS OF COMPLEX ELECTRONIC VEHICLE CONTROL SYSTEMS

D-1 GENERAL

This Annex defines the special requirements for documentation, fault strategy and verification with respect to the safety aspects of Complex Electronic Vehicle Control Systems (*see D-2.3*) as far as this standard is concerned. This Annex may also be called, by special paragraphs in this standard, for safety related functions which are controlled by electronic system(s). This Annex

does not specify the performance criteria for 'The System' but covers the methodology applied to the design process and the information which must be disclosed to the technical service, for type approval purposes.

This information shall show that 'The System' respects, under normal and fault conditions, all the appropriate performance requirements specified elsewhere in this standard.

D-2 DEFINITIONS

For the purposes of this Annex following definitions shall apply:

D-2.1 Safety Concept, is a description of the measures designed into the system, for example within the electronic units, so as to address system integrity and thereby ensure safe operation even in the event of an electrical failure.

The possibility of a fall-back to partial operation or even to a back-up system for vital vehicle functions may be a part of the safety concept.

D-2.2 Electronic Control System, means a combination of units, designed to co-operate in the production of the stated vehicle control function by electronic data processing.

Such systems, often controlled by software, are built from discrete functional components such as sensors, electronic control units and actuators and connected by transmission links. They may include mechanical, electro-pneumatic or electro-hydraulic elements. 'The System', referred to herein, is the one for which type approval is being sought.

D-2.3 Complex Electronic Vehicle Control Systems, are those electronic control systems which are subject to a hierarchy of control in which a controlled function may be over-ridden by a higher level electronic control system/function. A function which is over-ridden becomes part of the complex system.

D-2.4 Higher-Level Control, systems/functions are those which employ additional processing and/or sensing provisions to modify vehicle behaviour by commanding variations in the normal function(s) of the vehicle control system. This allows complex systems to automatically change their objectives with a priority which depends on the sensed circumstances.

D-2.5 Units, are the smallest divisions of system components which will be considered in this Annex, since these combinations of components will be treated as single entities for purposes of identification, analysis or replacement.

D-2.6 Transmission Links, are the means used for inter-connecting distributed units for the purpose of conveying signals, operating data or an energy supply.

This equipment is generally electrical but may, in some part, be mechanical, pneumatic or hydraulic.

D-2.7 Range of Control, refers to an output variable and defines the range over which the system is likely to exercise control.

D-2.8 Boundary of Functional Operation, defines the boundaries of the external physical limits within which the system is able to maintain control.

D-3 DOCUMENTATION

D-3.1 Requirements

The manufacturer shall provide a documentation package which gives access to the basic design of 'The System' and the means by which it is linked to other vehicle systems or by which it directly controls output variables. The function(s) of 'The System' and the safety concept, as laid down by the manufacturer, shall be explained. Documentation shall be brief, yet provide evidence that the design and development has had the benefit of expertise from all the system fields that are involved. For periodic technical inspections, the documentation shall describe how the current operational status of 'The System' can be checked.

D-3.1.1 Documentation shall be made available in two parts:

- a) The formal documentation package for the approval, containing the material listed in **D-3** (with the exception of that of **D-3.4.4**) which shall be supplied to the technical service at the time of submission of the type approval application. This will be taken as the basic reference for the verification process set out in **D-4**.
- b) Additional material and analysis data of **D-3.4.4** which shall be retained by the manufacturer, but made open for inspection at the time of type approval.

D-3.2 Description of the functions of 'The System'

A description shall be provided which gives a simple explanation of all the control functions of 'The System' and the methods employed to achieve the objectives, including a statement of the mechanism(s) by which control is exercised.

D-3.2.1 A list of all input and sensed variables shall be provided and the working range of these defined.

D-3.2.2 A list of all output variables which are controlled by 'The System' shall be provided and an indication given, in each case, of whether the control is direct or via another vehicle system. The range of control (*see D-2.7*) exercised on each such variable shall be defined.

D-3.2.3 Limits defining the boundaries of functional operation (*see D-2.8*) shall be stated where appropriate to system performance.

D-3.3 System Layout and Schematics

D-3.3.1 Inventory of Components

A list shall be provided, collating all the units of 'The System' and mentioning the other vehicle systems,

which are needed to achieve the control function in question. An outline schematic showing these units in combination shall be provided with both the equipment distribution and the interconnections made clear.

D-3.3.2 Functions of the Units

The function of each unit of 'The System' shall be outlined and the signals linking it with other units or with other vehicle systems shall be shown. This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.

D-3.3.3 Interconnections

Interconnections within 'The System' shall be shown by a circuit diagram for the electric transmission links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified diagrammatic layout for mechanical linkages.

D-3.3.4 Signal Flow and Priorities

There shall be a clear correspondence between these transmission links and the signals carried between units. Priorities of signals on multiplexed data paths shall be stated wherever priority may be an issue affecting performance or safety as far as this standard is concerned.

D-3.3.5 Identification of Units

Each unit shall be clearly and unambiguously identifiable (for example by marking for hardware and marking or software output for software content) to provide corresponding hardware and documentation association.

Where functions are combined within a single unit or indeed within a single computer, but shown in multiple blocks in the block diagram for clarity and ease of explanation, only a single hardware identification marking shall be used. The manufacturer shall, by the use of this identification, affirm that the equipment supplied conforms to the corresponding document.

D-3.3.5.1 The identification defines the hardware and software version and, where the latter changes such as to alter the function of the unit as far as this standard is concerned, this identification shall also be changed.

D-3.4 Safety Concept of the Manufacturer

D-3.4.1 The manufacturer shall provide a statement which affirms that the strategy chosen to achieve 'The System' objectives will not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this standard.

D-3.4.2 In respect of software employed in 'The System', the outline architecture shall be explained and the design methods and tools used shall be identified. The manufacturer shall be prepared, if required, to

show some evidence of the means by which they determined the realization of the system logic, during the design and development process.

D-3.4.3 The manufacturer shall provide the technical authorities with an explanation of the design provisions built into 'The System' so as to generate safe operation under fault conditions. Possible design provisions for failure in 'The System' are for example:

- a) Fall-back to operation using a partial system.
- b) Change-over to a separate back-up system.
- c) Removal of the high level function.

In case of a failure, the driver shall be warned for example by warning signal or message display. When the system is not deactivated by the driver, e.g. by turning the ignition (run) switch to 'off', or by switching off that particular function if a special switch is provided for that purpose, the warning shall be present as long as the fault condition persists.

D-3.4.3.1 If the chosen provision selects a partial performance mode of operation under certain fault conditions, then these conditions shall be stated and the resulting limits of effectiveness defined.

D-3.4.3.2 If the chosen provision selects a second (back-up) means to realise the vehicle control system objective, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.

D-3.4.3.3 If the chosen provision selects the removal of the higher level function, all the corresponding output control signals associated with this function shall be inhibited, and in such a manner as to limit the transition disturbance.

D-3.4.4 The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety.

This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations.

The chosen analytical approach(es) shall be established and maintained by the manufacturer and shall be made open for inspection by the technical service at the time of the type approval.

D-3.4.4.1 This documentation shall itemize the parameters being monitored and shall set out, for each fault condition of the type defined in **D-3.4.4**, the warning signal to be given to the driver and/or to service/technical inspection personnel.

D-4 VERIFICATION AND TEST

D-4.1 The functional operation of 'The System', as laid out in the documents required in **D-3** shall be tested as follows:

D-4.1.1 *Verification of the Function of 'The System'*

As the means of establishing the normal operational levels, verification of the performance of the vehicle system under non-fault conditions shall be conducted against the manufacturer's basic benchmark specification unless this is subject to a specified performance test as part of the approval procedure of this or another standard.

D-4.1.2 *Verification of the Safety Concept of D-3.4*

The reaction of 'The System' shall, at the discretion of the type approval authority, be checked under the influence of a failure in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal faults within the unit.

D-4.1.2.1 The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate.

ANNEX E

(Clause 6)

VEHICLE CHARACTERISTICS

E-1 Model

E-2 Number of axles (Steered/Non-steered)

E-3 Gross vehicular weight (GVW)

E-4 Maximum recommended mass for:

- a) Front axle:
- b) Rear axle:
- c) Intermediate axle:

E-5 Wheel base (Laden)

E-6 Track of steered axle(s) (Laden)

E-7 Steering gear type

E-8 Steering gear ratio

E-9 Steering wheel diameter

E-10 Tyre size and ply rating and tyre pressure

E-11 Tyre type (radial/diagonal/cm)

E-12 Wheel lock angle

	<i>Inner</i>	<i>Outer</i>
Left		
Right		

E-13 Number of steering wheel rotations from lock to lock

E-14 Caster angle (Laden)

E-15 Minimum turning circle diameter

E-16 Co-ordination of outermost point which defines the turning circle

E-17 Pressure setting in case of power steering

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: TED 4 (644).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002

Telephones : 2323 0131, 2323 3375, 2323 9402

Website: www.bis.org.in

Regional Offices:

Telephones

Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	{ 2323 7617 2323 3841
Eastern	: 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700054	{ 2337 8499, 2337 8561 2337 8626, 2337 9120
Northern	: SCO 335-336, Sector 34-A, CHANDIGARH 160022	{ 60 3843 60 9285
Southern	: C.I.T. Campus, IV Cross Road, CHENNAI 600113	{ 2254 1216, 2254 1442 2254 2519, 2254 2315
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	{ 2832 9295, 2832 7858 2832 7891, 2832 7892

Branches: AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISAKHAPATNAM.